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ORIGINAL RESEARCH

THE CLINICAL, FUNCTIONAL AND BIOMECHANICAL PRESENTATION OF PATIENTS WITH SYMPTOMATIC HIP ABDUCTOR TENDON TEARS

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ABSTRACT

Background: Hip abductor tendon (HAT) tearing is commonly implicated in greater trochanteric pain syndrome (GTPS), though limited information exists on the disability associated with this condition and specific presentation of these patients.

Purpose: To describe the clinical, functional and biomechanical presentation of patients with symptomatic HAT tears. Secondary purposes were to investigate the association between these clinical and functional measures, and to compare the pain and disability reported by HAT tear patients to those with end-stage hip osteoarthritis (OA).

Study Design: Prospective case series.

Methods: One hundred forty-nine consecutive patients with symptomatic HAT tears were evaluated using the Harris (HHS) and Oxford (OHS) Hip Scores, SF-12, an additional series of 10 questions more pertinent to those with lateral hip pain, active hip range of motion (ROM), maximal isometric hip abduction strength, six-minute walk capacity and 30-second single limb stance (SLS) test. The presence of a Trendelenburg sign and pelvis-on-femur (POF) angle were determined via 2D video analysis. An age matched comparative sample of patients with end-stage hip OA was recruited for comparison of all patient-reported outcome scores. Independent t-tests investigated group and limb differences, while analysis of variance evaluated pain changes during the functional tests. Pearson's correlation coefficients investigated the correlation between clinical measures in the HAT tear group.

Results: No differences existed in patient demographics and patient-reported outcome scores between HAT tear and hip OA cohorts, apart from significantly worse SF-12 mental subscale scores ($p = 0.032$) in the HAT tear group. Patients with HAT tears demonstrated significantly lower ($p < 0.05$) hip abduction strength and active ROM in all planes of motion on their affected limb. Pain significantly increased throughout the 30-second SLS test for the HAT tear group, with 57% of HAT tear patients demonstrating a positive Trendelenburg sign. POF angle during the test was not significantly associated with pain.

Conclusion: Patients with symptomatic HAT tears demonstrate poor function, and report pain and disability similar to or worse than those with end-stage hip OA. This information better defines and differentiates the presentation of these patients.

Level of Evidence: Level 3 case-controlled study, with matched comparison

Keywords: Assessment, clinical outcomes, hip abductor tears, patient presentation

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INTRODUCTION

Greater trochanteric pain syndrome (GTPS) is a non-specific term used to describe the clinical condition of greater and peri-trochanteric hip pain and tenderness.[1-6] It affects 10-25% of the general population,[5-7] is experienced by 10–20% of all patients with hip problems presenting in primary care,[7,8] and is more prevalent in females[5,7] and sedentary 40–60 year olds.[9] While a number of conditions are associated with GTPS including trochanteric bursitis, external coxa saltans and gluteal tendinopathy,[3,4,10] better understanding of the condition along with advanced imaging and surgical findings has revealed a common cause to be hip abductor tendon (HAT) tears.[2,11,12] While the true incidence of hip abductor tendon tears is unknown, it has been estimated that almost 25% of late-middle aged women and more than 10% of late-middle aged men will develop a HAT tear.[13]

GTPS is generally characterized by pain in the lateral hip and/or buttock,[6,14] often radiating laterally and/or posteriorly down the thigh,[14,15] and occasionally below the knee.[15] There is tenderness on palpation over the greater trochanter,[6] with pain aggravated further by pressure,[14] as well as lying on the affected side.[6] While it has been reported that hip ROM is often not affected in GTPS patients,[3] patients with hip abductor tears generally limp during ambulation making improvement of limp a common goal of surgical repair.[16-18] GTPS patients also experience pain/difficulty with prolonged standing or transitioning to a standing position, climbing stairs and sitting with the affected leg crossed.[6] Resisted hip external rotation (in flexion) has demonstrated high sensitivity (88%) and specificity (97.3%) for abductor tendon tears.[4] Pain with sustained single leg stance beyond 30 seconds may also be a useful clinical test.[4]

While the aforementioned findings have been generalized to patients with GTPS, there is no research that has attempted to identify the specific presentation of patients with symptomatic HAT tears. Earlier identification of HAT tears may permit early intervention and more targeted management and/or referral strategies for the therapist, assist in developing specific clinical evaluation tools for patients with a diagnosis of GTPS (and/or HAT tears) or those presenting with lateral hip pain, and permit better design of future studies investigating the conservative and surgical treatment of tendon tears. Patients with symptomatic HAT tears often go undiagnosed in GTPS sufferers for some time, or are misdiagnosed as 'bursitis' or 'hip OA', which may explain the long duration of symptoms and failed conservative treatments these patients often endure. Therefore, the purpose of this study was to describe the clinical, functional and biomechanical presentation and disability of patients with symptomatic HAT tears. Secondary purposes were to investigate the association between these clinical and functional measures, and to compare the pain and disability reported by patients with HAT tears to those with end-stage hip OA.

METHODS

Hip Abductor Tendon (HAT) Tear Patients

Between August 2012 and March 2016, a consecutive series of 149 patients with symptomatic HAT tears (128 females, 21 males) were referred for pre-operative counselling and clinical evaluation prior to their scheduled HAT repair. The clinical diagnosis of HAT tearing was confirmed by Magnetic Resonance Imaging (MRI) in all patients and included partial and full thickness tears of gluteus medius and/or minimus. For the current analysis, patients were excluded if they were symptomatic bilaterally (n = 8) or had evidence of advanced (Grade 2-4)[19] and/or symptomatic hip OA on MRI (n = 8). In all included patients, the predominant presenting symptom was lateral-sided trochanteric pain with radiation down the lateral leg, and not below the knee joint line. Patients were also excluded if they had undergone prior hip surgery including THA (n = 12), prior failed HAT repair (n = 2), ITB release and/or bursectomy (n = 2). The analysis was completed with 124 patients (104 females, 20 males), with a mean age of 63.4 years (range 43-82) and body mass index (BMI) of 27.6 (range 20.0-40.2) (Table 1). Patients had undergone an average of 3.1 (range 1-8) prior corticosteroid injections and reported a mean duration of symptoms (DOS) of 3.6 years (range 6 months – 18 years). Patients provided written informed consent prior to study enrolment, and ethics approval was obtained from the Hollywood Private Hospital Human Research Ethics Committee (HPH348). This study conformed to the STROBE (Strengthening the reporting of observational studies in epidemiology) checklist.

Table 1. *Characteristics of the hip abductor tendon tear (HAT) and end-stage hip osteoarthritis (OA) patient groups*

Variable	HAT Patients (n=124)		End-stage Hip OA Patients (n=30)		p value
	Mean (SD)	Range	Mean (SD)	Range	
Gender (female/male)	104/20	N/A	25/5	N/A	N/A
Age (y)	63.4 (9.3)	43-82	63.2 (9.4)	44-77	0.801
Height (m)	1.64 (0.07)	1.49-1.83	1.70 (0.09)	1.53-1.88	0.499
Weight (kg)	74.4 (14.9)	50.0-124.0	76.2 (16.2)	43.7-105.5	0.184
Body Mass Index	27.6 (4.7)	20.0-40.2	27.1 (4.1)	18.4-33.6	0.280
Injections (n)	3.1 (1.8)	1-8	N/R	N/R	N/A
Duration of Symptoms (y)	3.6 (2.2)	0.5-18	N/R	N/R	N/A

NR = not reported; N/A = not applicable.

Hip Osteoarthritis Patients

A total of 30 patients with end-stage hip OA scheduled for THA were recruited to provide comparison of specific patient-reported outcome (PRO) measures used in the current study, to that of patients with symptomatic HAT tears (Table 1). Given GTPS is a condition more prevalent in females and the cohort with HAT tears confirmed this, in order to best match the groups targeted sampling was utilized to attain a comparable female/male ratio. Therefore, once the group with HAT tears was confirmed (n = 124, 104 females, 20 males, [16% males]), recruitment of males with end-stage hip OA was ceased at n = 5 (17% of 30 patients) and female recruitment continued until the total of 30 patients was reached. This hip OA group then included 25 females and five males, with a mean age of 63.2 years (range 44-77) and BMI of 27.1 (range 18.4-33.6) (Table 1). While none of the hip OA patients presented with lateral hip pain and/or tenderness (with or without pain radiating laterally and/or posteriorly down the outer thigh), no attempt was made to diagnose the presence or absence of asymptomatic underlying GTPS pathology via ultrasound or MRI in the hip OA group.

Patient-reported Outcome (PRO) Measures

All HAT tear and hip OA patients completed a number of PRO measures to evaluate hip pain, symptoms and disability, including the Harris Hip Score (HHS)[20] and Oxford Hip Score (OHS).[21,22] While these clinical tools have not been validated in a cohort with GTPS or HAT tears, nor have any existing hip PROs, we employed them given they had been the two most commonly utilized clinical tools for assessing outcomes before and after HAT repair surgery.[23] The 12-item Short Form Health Survey (SF-12) was also employed, which evaluated the general health of the patient producing a mental (MCS) and physical component subscale (PCS).

An additional series of questions was compiled and completed by all HAT tear and hip OA patients, which were grouped to form a novel PRO (Table 2). For the purpose of this manuscript it has been called the 'GTPS PRO', and it was used to quantify the severity of common symptoms, impairments and functional limitations reported by patients with GTPS that are often excluded from existing hip PRO scores. The final list of 10 items was decided upon by the author team, following review of existing hip PROs and patient cohorts they were originally developed for (i.e. hip OA patients), along with 10 years of clinical and anecdotal experience the author team has with operating on and rehabilitating patients with HAT tears. The GTPS PRO items were each scored on a scale from 0 (None) to 5 (Extreme) (Table 2).

Functional and Biomechanical Measurement Procedures

The patients with HAT tears performed a series of functional tests, each administered by a single physical therapist with 15 years of clinical experience, particularly with undertaking the chosen tests. First, active hip range of motion (ROM) was evaluated on

Table 2. *The Greater Trochanteric Pain Syndrome Patient-reported Outcome (GTPS PRO) score, which included additional items aimed at investigating common symptoms, impairments and functional limitations reported by patients with GTPS*

	None	Very mild	Mild	Moderate	Severe	Extreme
1. Do you have any pain:						
a) Over the outside of your hip?	0	1	2	3	4	5
b) Over the outside of your thigh?	0	1	2	3	4	5
c) With pressure (or pressing) on your outer hip area?	0	1	2	3	4	5
d) Radiating down to your knee?	0	1	2	3	4	5
e) When your affected leg is crossed over your other leg?	0	1	2	3	4	5
2. Do you have any pain and/or difficulty:						
a) Sleeping on your affected side?	0	1	2	3	4	5
b) Standing on your affected leg?	0	1	2	3	4	5
3. Because of your hip, do you:						
a) Limp during walking?	0	1	2	3	4	5
b) Fatigue quickly during undertaking normal daily activities?	0	1	2	3	4	5
c) Use a walking aid (i.e. crutch) or shopping trolley at the shops?	0	1	2	3	4	5

both the affected and unaffected limb in all planes using either a hand-held bubble inclinometer (hip flexion in supine, internal and external rotation in prone) or a Jamar® long arm goniometer (hip adduction and abduction in supine, extension in standing). These positions of active hip ROM evaluation were chosen with factors in mind such as assessor ease and accuracy, minimizing the gravitational component of lifting a limb, patient comfort and not being as restricted in measurement by concomitant musculoskeletal pathology or abnormality (such as restricted hip and/or knee flexion could limit accuracy of measurement of hip internal and/or external rotation in a flexed hip position). Standardized feedback was provided across all patients in undertaking the aforementioned measures, and patients were instructed to work into each plane of motion as far as they possibly could to the end point of range, or to when pain could no longer be tolerated. All patients were educated on potential compensatory movements (i.e. such as forward trunk lean and excessive lumbar lordosis during standing hip extension), and these compensatory mechanisms were monitored and addressed as required by the assessor. For all planes of active hip ROM, absolute values and limb symmetry indices (LSIs) were calculated (LSIs were expressed as the range of the affected limb, as a percentage of the unaffected limb).

Second, a 30-second single leg stance (SLS) test was conducted, almost identically to that previously used in patients with gluteal tendinopathy.[4] While the originally published test requires patients to report the presence/absence of hip pain within 0–5 seconds (immediate), 6–15 seconds (early) and/or or 16–30 seconds (late), patients were asked to verbally report their severity of pain immediately prior to the initiation of the test and then at 10, 20 and 30 seconds into the test, on a whole number rating scale (NRS) of 0 (no pain) to 10 (worst pain). In addition, frontal plane hip biomechanical parameters were evaluated from video obtained using a Sony HDR-PJ200 digital video camera (Sony Corporation, Tokyo, Japan) which was set up approximately three meters in front of the patient, with the camera height set at the level of the anterior superior iliac spines (ASISs). The on-screen video camera display was then zoomed as required to ensure the feet could be viewed and the patient's head was truncated (Figure 1). Video was collected during the entire duration of the 30-second SLS test. Patients wore comfortable pants and walking shoes throughout all tests and, prior to testing, three retro-reflective markers were attached to the skin of the pelvis (left and right ASIS) and sternal notch. For patients in which the centre of the patella could not be easily observed visually, a fourth marker was placed in the central patella (Figure 1). Once captured, video images of the 30-second SLS test (on the affected limb) were projected onto a 19-inch flat screen monitor and digitised using Silicon Coach Professional (Silicon Coach Professional Version 6.0, Dunedin, New Zealand). The video data in this study was used to evaluate pelvis-on-femur (POF) angle during the 30-second SLS test at the aforementioned time points (immediately prior to the start of the test during bilateral weight bearing stance, and at 10, 20 and 30 seconds into the test). POF angle (degrees) was measured as an angle made between the ASIS on the unaffected swing leg, the ASIS on the affected support leg and the knee joint centre on the affected support leg (Figure 1).

Third, patients with HAT tears performed the six minute walk test (6MWT) to assess the maximum comfortable distance the patient could walk in a six minute time period.[24] The patient was instructed to walk back and forth between two markers set 25 m apart, and asked to walk "as far and fast as they comfortably could for the entire six minutes". A NRS (0 = no pain; 10 = worst pain) was again employed immediately prior to the test and then at 2, 4 and 6 minutes into the test, to evaluate pain severity.

Finally, the maximal isometric hip abduction strength was assessed on both the affected and unaffected limb in HAT tear patients, using a T5 Cable Tensiometer (Pacific Scientific Company, Los Angeles). In an upright standing position, with the patient able to bear as much weight as was required through their upper body supported alongside their trunk, patients were asked to abduct their leg as hard as they could against the cable anchored just above their lateral malleolus (Figure 2). The test was undertaken three times for each limb, initiated on the unaffected limb and then alternated between the unaffected and affected side, with the maximum score of the three trials used for analysis. The patient was instructed to maintain an upright trunk and not force their hips out with the test leg and, therefore, to ensure this was the case the hands of the assessor were placed on either hip of the patient

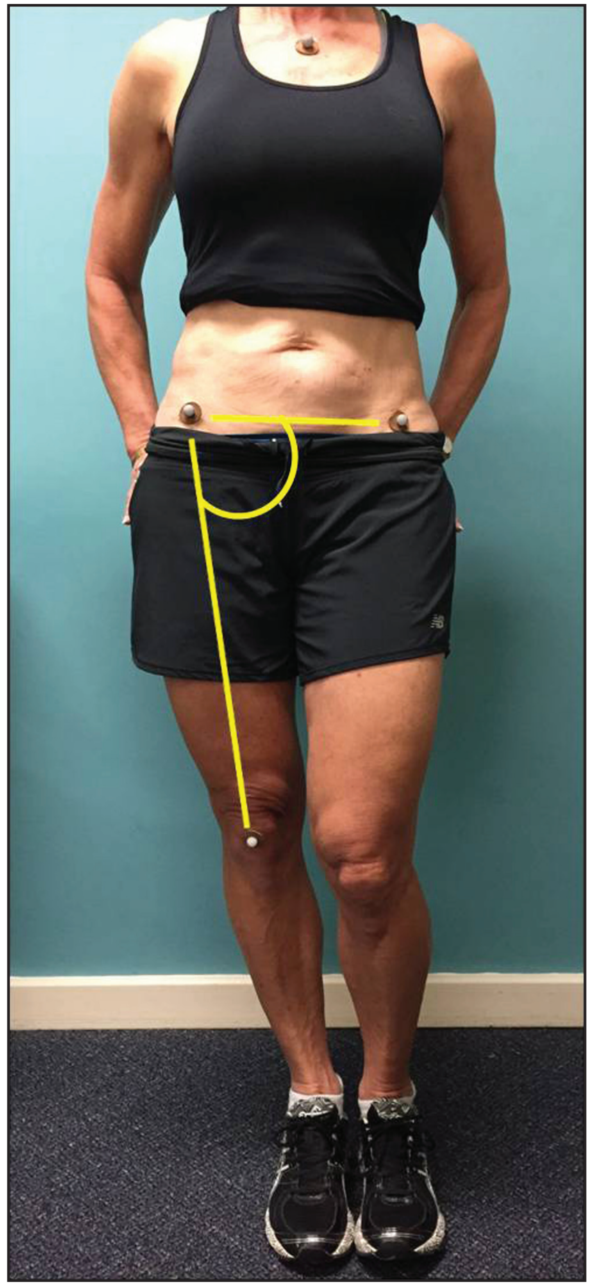

Figure 1. *Measurement of pelvis-on-femur (POF) angle employed during the 30-second single leg stance test. POF angle (degrees) was measured as an angle made between the anterior superior iliac spine (ASIS) on the unaffected swing leg, the ASIS on the affected support leg and the knee joint center on the affected support leg.*

during the test to minimize compensatory strategies that can occur in standing. Other studies have evaluated hip abductor strength in the side lying position, and evaluating abductor strength in side lying is frequently employed in clinical settings.[25] However, the evaluation of limb symmetry limited the applicability of using the side lying position due

Figure 2. *Set up and measurement of maximal isometric hip abductor strength in the supported standing position, using a T5 Cable Tensiometer (Pacific Scientific Company, Los Angeles). The patient was able to bear as much body weight as required through their upper body supported alongside their trunk, and was asked to abduct their leg as hard as they could against the cable anchored above their lateral malleolus. To minimize compensatory strategies by the patient, the hands of the assessor were placed on either hip of the patient during the test (not shown), and they were instructed to maintain an upright trunk and not force their hips out with the test leg.*

to compression pain when lying on the affected limb, while evaluating the non-affected limb. Supine (neutralizes the gravitational effect and avoids the requirement of individuals lying on their injured side)[26] and standing (reported to be more functional as the majority of daily living activities involve hip abduction performed in this position)[27] positions has also been employed, so the supported standing position was employed. For strength, absolute values and limb symmetry indices (LSIs) were calculated (LSIs were expressed as the strength of the affected limb, as a percentage of the unaffected limb).

Data and Statistical Analysis

Means, standard deviations and ranges were calculated for all PRO, clinical and biomechanical outcomes. Independent t-tests were employed to evaluate differences in patient demographics between the HAT tear and end-stage hip OA cohorts, as well as all PRO measures. Within the HAT tear cohort, paired sample t-tests were used to investigate differences between the affected and unaffected limb in active hip ROM and hip abduction strength. A one-way repeated measures analysis of variance (ANOVA) was used to evaluate the change in pain during the 6MWT, as well as the change in pain and POF angle during the 30-second SLS test, as well as the association between the two variables. In the presence of significant ANOVA results, t-tests were further employed to see between which time points these differences indeed occurred. Pearson's coefficients were used to investigate the correlations between PROs (HHS, OHS and SF-12), functional measures (six minute walk distance, maximal isometric hip abductor strength, limb symmetry index between the affected and unaffected limb in hip abductor strength and active ROM measures) and pain (upon completion of the 6MWT and 30-second SLS test). Statistical analysis was performed using SPSS software (SPSS, Version 17.0, SPSS Inc., USA), while statistical significance was determined at $p < 0.05$.

RESULTS

Of the 124 HAT tear patients included in this analysis, all patients completed the aforementioned PRO measures, active hip ROM evaluation and 6MWT. One HAT tear patient was unable to complete the maximal isometric hip abduction strength assessment, while five HAT tear patients were unable to undertake the 30-second SLS test or 6MWT, all due to the requirement of a single forearm crutch.

No differences existed in patient demographics between the HAT tear and hip OA cohorts (Table 1). While the HAT tear group reported a significantly worse score for the SF-12 MCS ($p = 0.032$), no other differences ($p > 0.05$) in the validated PRO measures

Table 3. *Patient reported outcome (PRO) measures for the hip abductor tendon (HAT) tear and end-stage hip osteoarthritis (OA) patient groups. Data presented as means (SD) and ranges*

PRO Measure	Harris Hip Score (0-100)	Oxford Hip Score (0-48)	SF-12 (PCS)	SF-12 (MCS)	GTPS PRO score items (1-10)									
					1A	1B	1C	1D	1E	2A	2B	3A	3B	3C
HAT Tear Patients	60.7 (19.6)	25.9 (8.4)	34.6 (10.1)	43.9 (11.8)	3.1 (0.8)	2.7 (1.2)	3.4 (0.9)	2.8 (1.4)	3.3 (0.9)	4.1 (1.0)	4.0 (0.8)	3.2 (1.0)	3.1 (1.1)	1.5 (1.5)
Range	22.8-100	11-46	9.0-57.8	20.4-70.8	1-4	0-5	2-5	0-5	2-5	1-5	2-5	1-5	0-5	0-5
End-stage Hip OA Patients	60.8 (15.5)	27.0 (7.2)	36.8 (8.8)	54.3 (9.9)	1.1 (0.7)	0.9 (0.9)	1.2 (0.9)	0.9 (0.9)	1.7 (0.7)	2.0 (0.6)	2.4 (0.8)	3.3 (1.2)	2.6 (1.1)	0.4 (0.6)
Range	23.0-88.6	11-40	19.2-56.7	31.6-70.0	0-3	0-3	0-4	0-3	1-3	1-4	1-4	1-5	0-5	0-2
p value	0.983	0.586	0.331	0.032	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	0.694	0.048	0.003

SF-12 = 12 item short form health survey, PCS = physical component score, MCS = mental component score, GTPS PRO (Greater Trochanteric Pain Syndrome Patient-reported Outcome).

existed between the HAT tear and hip OA groups (Table 3). For the GTPS PRO, HAT tear patients reported a significantly higher level ($p < 0.05$) of pain and/or difficulty when compared to the hip OA patients, in nine of the 10 included items (the only question that was not significantly different between the HAT tear and hip OA patients was the patient's subjective report of a limp during walking) (Table 3).

For the HAT tear cohort, active hip ROM in all planes was significantly lower ($p < 0.05$) on the affected limb, compared with the unaffected limb, with the mean LSI for active hip flexion at 86.2% though all other hip ROM LSIs below 80% (Table 4). While the LSI for maximal isometric hip abduction strength was 92.7%, it was still significantly lower ($p < 0.05$) on the affected limb, compared with the unaffected limb (Table 4). During the 30-second SLS test, reported pain in the HAT tear group significantly increased from 2.3 immediately prior to the test to 5.1 upon its completion, and t-tests indicated that pain significantly increased between every time point up until the completion of the test. At the completion of the test, 93% (n = 111) of HAT tear patients reported pain, with 57% (n = 68) of patients demonstrating a positive Trendelenburg sign (Table 5). POF angle during the test did not significantly change, and no significant correlation existed between pain and POF angle throughout the test (Table 5). A mean of 391m was observed for the 6MWT in HAT tear patients, with

Table 4. *Maximal isometric hip abductor strength and active range of motion between the affected and unaffected sides in the hip abductor tendon (HAT) tear patient group. Data are presented using means (SD) and range for the affected and unaffected limbs, along with p values. Limb Symmetry Indices (LSIs) are also shown for each variable (the affected limb as a percentage of the unaffected limb)*

Hip	Maximal Isometric Hip Abductor Strength (kg)	Flexion (degrees)	Extension (degrees)	Abduction (degrees)	Adduction (degrees)	External Rotation (degrees)	Internal Rotation (degrees)
Affected Hip	15.9 (3.5)	102.8 (17.4)	14.2 (5.2)	31.6 (12.1)	15.9 (6.3)	30.3 (8.9)	26.7 (10.8)
Range	10.8-26.8	60-140	5-27	5-58	7-42	8-50	5-50
Unaffected Hip	17.4 (4.7)	119.3 (9.7)	20.8 (5.7)	45.7 (9.2)	24.2 (7.6)	38.1 (7.6)	38.8 (7.8)
Range	10.8-37.4	95-140	12-35	25-68	15-45	25-62	20-58
p value (affected versus unaffected side)	0.002	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001
Limb Symmetry Index (LSI)	92.7%	86.2%	68.3%	69.1%	65.7%	79.5%	68.8%

Table 5. *The number and percentage of patients in the hip abductor tendon (HAT) tear group with pain, mean severity of pain (0-10), presence of a positive Trendelenburg sign, pelvis on femur (POF) angle, and the correlation between pain and POF angle, immediately prior to (bilateral stance) and at 10, 20 and 30 seconds into the 30-second single leg stance test. Data are reported as means (SD) and range, unless otherwise indicated.*

Time	Pain, n (%)	Pain (0-10)	+ve Trendelenburg Sign (n)	POF Angle (degrees)	Correlation (p value)
Pre-test	78 (66%)	2.3 (0-8)	N/A	85.0 (78-89)	N/A
10 secs	104 (87%)	3.9 (0-9)	62	85.1 (75-94)	-0.15 (0.212)
20 secs	108 (91%)	4.6 (0-10)	62	84.7 (73-92)	-0.10 (0.530)
30 secs	111 (93%)	5.1 (0-10)	68	83.1 (73-92)	-0.15 (0.302)
p value	N/A	<0.0001	N/A	0.200	N/A

N/A – not applicable

Table 6. *Total distance walked by the hip abductor tendon (HAT) tear group during the six-minute walk test (6MWT), as well as pain (0-10) reported initially prior to, and at 2, 4 and 6 minutes into the walk test. Data are displayed as means (SD) and range*

6MWT Distance (m)	Pain (pre-test)	Pain (2 mins)	Pain (4 mins)	Pain (6 mins)	p value
391 (108)	2.9 (2.5)	3.9 (2.8)	4.5 (2.9)	5.2 (2.9)	<0.0001
105-581	0-8	0-9	0-10	0-10	

pain significantly increasing over the duration of the test (Table 6). T-tests indicated that pain significantly increased between every time point up until the completion of the 6MWT.

The HHS, OHS and SF-12 PCS reported in the HAT tear group were all significantly correlated with each other (Table 7), with the strength of these associations generally good to excellent.[28] The SF-12 MCS was not significantly associated with any other PROs (Table 7), with the strength of associations between the SF-12 MCS and other PROs fair at best.[28] The HHS, OHS and SF-12 PCS were all significantly and negatively correlated with active hip flexion, abduction, adduction and external rotation ROM (Table 7). While this indicated that a greater limb symmetry deficit between the affected and unaffected limbs in these active ROM measures was associated with poorer clinical status in HAT tear patients, the strength of these associations was fair at best.[28] The HHS, OHS and SF-12 PCS were positively correlated with six-minute walk distance with the strength of associations moderate-good.[28] These PROs were also significantly and negatively correlated with pain upon completion of both the 6MWT and 30-second SLS test (Table 7), with the strength of associations good-excellent.[28] Maximal isometric hip abductor strength on the affected limb, six–minute walk distance, pain upon completion of the 6MWT and pain at completion of the 30-second SLS test, were all significantly correlated with each other (Table 7), though the strength of these associations were varied and ranged from fair-excellent.[28] The limb symmetry deficit in maximal isometric hip abductor strength between the affected and unaffected limbs in HAT tear patients was not significantly correlated with any of the other scores.

DISCUSSION

GTPS encompasses a range of conditions; however, advanced imaging and surgical findings have revealed that HAT tears may be a strong contributing factor to the pain and disability in GTPS patients.

Table 7. *Pearson's correlation coefficients between the clinical and functional scores in the hip abductor tendon (HAT) tear group*

Variable	HHS	OHS	SF-12 (PCS)	SF-12 (MCS)	Flex ROM (LSI)	Ext ROM (LSI)	Abd ROM (LSI)	Add ROM (LSI)	ER ROM (LSI)	IR ROM (LSI)	30 second SLS (pain)	Six-minute Walk (distance)	Six-minute Walk (pain)	Hip Abd Strength (absolute)	Hip Abd Strength (LSI)
HHS	1.00	0.79‡	0.70‡	0.29*	-0.41**	-0.08	-0.32*	-0.37*	-0.38**	-0.23	-0.60‡	0.58‡	-0.76‡	0.32*	0.12
OHS		1.00	0.67‡	0.44†	-0.41**	-0.087	-0.34*	-0.32*	-0.35*	-0.21	-0.63‡	0.65‡	-0.76‡	0.33*	0.06
SF-12 (PCS)			1.00	-0.02	-0.49‡	-0.23	-0.35**	-0.36**	-0.39**	-0.19	-0.59‡	0.56‡	-0.65‡	0.43†	0.16
SF-12 (MCS)				1.00	-0.04	0.02	-0.13	0.06	-0.12	-0.01	-0.18	0.30*	-0.19	0.05	-0.03
Flex ROM (LSI)					1.00	0.41**	0.44†	0.28*	0.36**	0.33*	0.47‡	-0.61‡	0.45†	-0.48‡	-0.1
Ext ROM (LSI)						1.00	0.68‡	0.65‡	0.34*	0.35**	0.15	-0.25	0.15	-0.26	-0.03
Abd ROM (LSI)							1.00	0.45†	0.25	0.29*	0.17	-0.30*	0.29*	-0.24	-0.12
Add ROM (LSI)								1.00	0.43†	0.25	0.41**	-0.32*	0.42**	-0.34*	-0.18
ER ROM (LSI)									1.00	0.38**	0.38**	-0.45†	0.39**	-0.46†	-0.11
IR ROM (LSI)										1.00	0.30*	-0.48‡	0.37**	-0.23	0.12
30 second SLS (pain)											1.00	-0.64‡	0.88‡	-0.35*	-0.07
6MWT (distance)												1.00	-0.70‡	0.55‡	0.12
6MWT (pain)													1.00	-0.41†	-0.18
Hip Abd Strength (absolute)														1.00	0.24
Hip Abd Strength (LSI)															1.00

*p<0.05; **p<0.01; †p<0.001; ‡p<0.0001.

HHS = Harris Hip Score; OHS = Oxford Hip Score; SF-12 = 12 item Short Form Health Survey; PCS = Physical Component Score; MCS = Mental Component Score; Flex = Flexion; Ext = Extension; Abd = Abduction; Add = Adduction; ER = External Rotation; IR = Internal Rotation; SLS = Single Leg Stance; 6MWT = six-minute walk test; LSI = limb symmetry index (affected limb as a percentage of the unaffected limb).

While the general presentation of patients with GTPS has been reported, there is no research that has attempted to identify the specific presentation and level of disability in symptomatic HAT tear patients. An improved understanding of these patients may allow better differentiation from other presenting conditions, such as hip OA, which may permit more targeted management and/or referral strategies for the therapist. Therefore, this study aimed to define the clinical presentation and disability associated with these tendon tears, as well as to investigate the association between different clinical measures and compare the pain and disability reported in those with HAT tears to patients with end-stage hip OA.

The results of this study demonstrated that patients with symptomatic HAT tears report pain and disability similar to those with end-stage hip OA. Furthermore, the SF-12 MCS was significantly lower in HAT tear patients, compared to OA patients, suggesting a significantly higher perceived level of disability and poorer quality of life in those with HAT tears. Fearon et al[29] recently suggested that people with GTPS demonstrate low levels of fulltime work participation, high levels of pain and dysfunction, and a reduced quality of life, indistinguishable from people with severe OA of the hip. The current study supports some of these previous findings.

Existing PROs may not capture the unique areas of pain, difficulty and/or dysfunction reported in GTPS and HAT tear patients. Many areas of concern commonly reported by GTPS patients are not included in the existing PROs; likely given they were originally developed for patients with hip fracture, OA or those undergoing THA.[20-22,30-43] Hip arthroscopy patients are younger, with a goal to often return to sports activities.[44] Therefore, other hip PRO measures were developed for those undergoing hip arthroscopy and/or hip-related pathologies specifically seen in young-to-middle-aged people.[45-48] Patients with hip tendon pathology (and tears) are often not young patients, and often do not have co-existent intra-articular pathology or symptomatic hip OA. GTPS patients often report lateral hip and/or buttock pain,[6,49] that may radiate laterally down the thigh[14,15] and occasionally below the knee.[15] There is often tenderness on trochanteric palpation,[6,50-53] with pain aggravated by lying on the affected side.[6] GTPS patients experience pain/

difficulty with prolonged standing or transitioning to a standing position, climbing stairs and sitting with the affected leg crossed.[6]

With this in mind, only one of aforementioned hip PRO measures inquires about pain/difficulty when sleeping on the affected side, while none inquire about lateral trochanteric pain and/or tenderness. None of the available hip PROs inquire about pain when standing on the affected limb, nor sitting with the affected leg crossed. Furthermore, few PROs inquire about the use of walking aids and only the HHS and OHS enquire about limp severity. Therefore, the GTPS PRO was developed by the authors, which aims to investigate and rate common symptoms, impairments and functional limitations reported by patients with GTPS that are often excluded from existing hip PRO scores. Apart from the presence of a limp during walking, patients with symptomatic tendon tears reported significantly more pain and/or difficulty than patients with end-stage hip OA in all remaining items.

It has been previously reported that hip movement is generally not affected in GTPS patients, largely due to the fact that these patients do not have OA.[3] However, this was not the case in the current study whereby patients with HAT tears demonstrated significantly reduced active hip ROM in all planes, compared with their unaffected side. Extremes of hip movement may be limited in the HAT tear patients due to pain that may occur with increased hip abductor activation and/or compression over the greater trochanter. In particular, positions of increased HAT compression over the greater trochanter and increased likelihood of provocation may include internal hip rotation, excessive hip adduction and/or flexion.[54,55]

Patients attained a mean of 391 meters during the 6MWT, with a significant increase in reported pain throughout the test. Higher reported pain and less distance covered during the test were significantly associated with poorer PRO scores in HAT tear patients. While six-minute walk capacity has not been evaluated in HAT tear patients previously, and it was not evaluated in the matched hip OA cohort, more recent existing literature in hip OA patients has demonstrated a mean of 643 meters in patients with radiographic and symptomatic hip OA,[56] as well as 450 meters[57] and 452 meters[58] in patients with end-stage hip OA scheduled for THA. Again, the current results reflect the severity and disability associated with symptomatic HAT tears.

While a significantly reduced isometric hip abductor strength profile was demonstrated in the affected limb of HAT tear patients, compared with the unaffected contralateral side, mean LSI values for hip abductor strength were still 93%. Furthermore, given that the hip abductor strength LSI was not significantly correlated with any of the other PROs or functional scores, the clinical relevance of the side-to-side strength difference remain unclear. However, this hip abductor strength deficit may be important to pelvic stability during weight bearing and SLS, and this study did report that of the 119 patients that completed the 30-second SLS test, 62 demonstrated a positive Trendelenburg sign at 10 seconds into the test, with 68 upon completion. Interestingly, while POF angle did decrease throughout the duration of the test, this fall was not statistically significant.

There are several inherent study limitations. First, this research was conducted using symptomatic HAT tear patients that had sought medical opinion for their condition and were planning to undergo HAT repair surgery. Therefore, this research cannot be generalized across all patients with tears, including those that are otherwise asymptomatic. Second, while an outcome of this study was to compare reported pain and disability of HAT tear patients to a group of patients with end-stage hip OA, an attempt to differentiate further to those with isolated bursitis or other conditions that may contribute to GTPS has not been made. This remains an area for future research, and in the authors' experience these tears often go misdiagnosed for hip OA or 'bursitis', or undiagnosed in GTPS sufferers for some time. This may explain the long duration of symptoms (mean 3.6 years) and failed conservative treatments (mean 3.1 injections) reported in this study.

Third, there are known limitations with the accuracy of assessing joint ROM using handheld goniometry, though it has been reported that the reliability of measurements improves when the assessment is performed by the same individual, using the same measurement tool and in standardized test positions.[59,60] Furthermore, active, rather than active-assisted or passive hip ROM was evaluated, with an underlying goal to assess how far each patient could actively move their hip into each plane of motion. However, it should be acknowledged that both active and passive ROM assessment may offer benefits in patient evaluation, particularly when looking to discriminate between those with HAT tendinopathy/tears and hip OA. Fourth, as mentioned previously hip abduction strength was evaluated in the supported standing position[27] and, while compensatory mechanisms can be adopted in this position by patients, every effort was made to to minimize these as discussed.

Fifth, 2D video imaging of patients was undertaken during their 30-second SLS test to more accurately evaluate the presence/absence of a Trendelenburg sign and measure POF angle (hip adduction) during weight bearing, along with its association with reported hip pain. While it was not the aim of this study, other biomechanical variables assessed during single limb weight bearing activities may add value to the functional evaluation of HAT tear patients, including lateral pelvic translation and compensatory trunk lean over the ipsilateral weight bearing hip.[61] Finally, a number of validated hip PRO measures exist and this study employed the HHS and OHS primarily to evaluate hip pain, symptoms and disability. This was in part due to the lack of a validated PRO measure for GTPS or HAT tear patients at study onset. However, the HHS and OHS have been reported as the two most common clinical tools used to evaluate the outcome of patients before and after HAT repair surgery.[23] Nevertheless, patients scored poorly in the HHS and OHS in this study, and these scores were comparable to those with end-stage hip OA. While we administered a series of additional questions to investigate concerns pertinent to GTPS patients that are often not included in other hip PROs, a PRO specific to evaluating the pain and disability associated with GTPS has been developed and validated more recently,[62] and could be employed in future research.

CONCLUSION

This is the first study to describe the specific clinical presentation and reported disability of patients with symptomatic HAT tears. These patients report pain severity and disability levels similar (or worse, as was the case with the SF-12 MCS) to that of patients with end-stage hip OA though, as expected, also report significantly more pain and/or difficultly in items specific to patients with GTPS. Patients displayed reduced active hip ROM and abductor strength, with poor six-minute walk performance that was worse than that reported in existing literature evaluating hip OA patients. The majority of patients demonstrated a positive Trendelenburg sign during the 30-second SLS test with pain significantly increasing throughout the test. This information should help the clinician to differentiate patients presenting with HAT tears or hip OA. Understanding the presentation of patients with HAT tears may stimulate future research about diagnosis and treatment of this condition.

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